

the race, and that $E = E_0 + kt$, where E_0 and k are constants. Calling E/t the rate of fatigue f , express this in terms of s .

Assuming that an animal going at s_0 miles per hour feels no fatigue, or when $s = s_0$, $f = 0$; find f in terms of s .

(1) Contains the general result; the law is that t is proportional to $y^{3/8}$ or $y^{1.125}$. It may be stated in various other ways; for example, that the average speed in each race is inversely proportional to the eighth root of y , or a race 256 times as far is done at half the average speed.

In short races there is increase of speed at the beginning and almost always increase near the end; and it may be that there is continuous change of speed during all record races. We have only average speeds recorded, unfortunately, but still I must consider this wonderful general law to be worthy of the attention of biologists.

(3) Contains a poor speculation of my own, good enough for such an examination; the answer to it is that f is equal to $E_0 c^8 (s^9 - s_0^9)$. There is nothing extraordinary in the fact that record bicycle races do not follow the law; they have been run on machines of varying quality.

The values of c found by Prof. Kennelly are, his distances y being in metres:—trotting horse, 0.0295; pacing horse, 0.0291; running horse, 0.0236; man running, 0.0588; man walking, 0.0861; man skating, 0.0385; man swimming, 0.381. Men rowing, four oars, 0.0628; two oars, 0.0768; singles, 0.0824.

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The Isothermal Layer of the Atmosphere.

THE investigation of the upper air which has been in progress during recent years has revealed conditions for which it is very hard to find an explanation. When Mr. Rotch first inaugurated observations on temperature and humidity by means of kites, it was hoped that the results obtained would solve many problems connected with meteorology, and this hope was strengthened when M. Teisserenc de Bort greatly extended the height to which observations could be made by his system of *ballons sondes*. It has not, however, been realised, and we seem to be as far as ever from knowing the cause and mechanism of the cyclonic storms that are so common in the oceanic parts of the temperate latitudes.

Since last June some forty balloons have been sent up in Great Britain, carrying with them a small instrument which draws automatically a pressure temperature diagram, and of these more than thirty have been recovered. The results confirm those previously obtained on the Continent, and no doubt can now remain about the existence of the curious isothermal layer in the atmosphere.

Briefly, the more important phenomena are these. As we ascend the temperature of the air decreases, at first often irregularly, with breaks and inversions, but after the first 10,000 feet (3 kilometres) have been passed with fair regularity, the usual decrease being about 3°·3 F. per 1000 feet (6° C. per kilometre). This continues to a height that varies, as a rule, from 30,000 feet to 40,000 feet. Nearly always at somewhere about this height the decrease suddenly ceases. Above this point the air in most cases gets a little warmer; occasionally, however, it continues to get cooler, but at a totally different rate, and we may take the remaining air to be at one practically uniform temperature in so far as change of height is concerned. This isothermal layer, as it has been called, has been reached in England more than thirty times. On the average its height is about 35,000 feet (10·7 kilometres), but the extreme values found were 25,500 feet and 49,000 feet. As a rule, it is higher than the mean when the barometer is high, and conversely. Its mean temperature was found to be -53°·6 F. (-47° C.), and the extremes were -22° F., at Ditcham Park, Hants, on July 24; -24° F., at Crinan, on July 26; -78° F., at Pyrton Hill, Oxfordshire, on September 12, 1907, and also on February 5, 1908; and -74° F., at Manchester, on November 7, 1907.

This mean value is considerably higher than the Continental one for previous years, but as thirty observations do not suffice to give a true mean, this may be accidental. Balloons have been sent up from five stations on the same day, and the temperatures over the stations have been found to differ widely. Thus on November 11 Mr.

Cave's balloon from Ditcham Park reached the isothermal layer at 36,000 feet, and its temperature was -42° F. Over Oxfordshire the height was 38,500 feet, and the temperature -58° F., while at the same time, which was a little after sunset, Mr. Petavel, at Manchester, found it at 37,000 feet, with a temperature of -74° F. This is not an isolated instance, and although the heights given may be uncertain to an extent of perhaps 5 per cent. or even more, it is very unlikely that the error in the temperature can exceed three or four degrees F. It may be accidental, but the temperature over Ditcham Park, which is near the sea, shows a tendency to exceed that over the Midlands. The balloons mostly drift to the eastward, the centre of their falling points being thirty-four miles E., 23° N., of the starting point. Doubtless several of the unfound balloons fell in the North Sea, as some have been returned from France and Holland.

Various suggestions have been made to account for these results. There is, of course, no difficulty about the general decrease of temperature with height, but why should the fall suddenly cease when from one-third to one-fourth of the mass of the atmosphere remains above? In general, the transition point is perfectly sharp and distinct. It is said that the vertical circulation ceases at this point, and no doubt the statement is true, but why should it cease? There is a further difficulty. The absence of vertical motion implies a condition of equilibrium, but how can there be equilibrium with such large horizontal differences of temperature? At the height of 40,000 feet the pressure is small, and therefore trifling changes of pressure produce large changes of volume and temperature; hence large changes of temperature might be expected if we could assume some horizontal force, comparable with gravity, and capable of producing changes of pressure without producing vertical motion. The horizontal acceleration due to centrifugal force in a curvilinear path and that produced on a moving body by the earth's rotation are too small; also it seems to me that these forces, being due to motion of the air, must produce some vertical circulation, which apparently does not exist.

The problem is one of the most interesting presented at the present time to physical science, and it is not unlikely that its solution might clear up many other puzzling questions.

W. H. DINES.

The Inheritance of "Acquired" Characters.

MR. ARCHDALL REID in his previous letter said (p. 293) "innate characters arise inevitably as the child develops, whereas some acquirements are more or less rare, but this is *only* because the stimulus of nutriment is inevitably received, whereas the stimulus of a particular use or injury may not be received. If, however, the latter be received, the acquirement arises just as inevitably as the innate characters." This latter statement seemed to me particularly incorrect for the reasons which I stated; and now Mr. Reid practically admits (p. 342) that it cannot be accepted as it stands, in face of the fact that the inherent tendencies of the germs of different human beings vary so much, and must therefore react variously to the stimulus of use.

My chief objection, however, to Mr. Reid's view was that contained in his statement that "in man the main difference between the infant and the adult is due to use acquirements made by the latter during development." His whole case in the discussion hinges upon this statement, by which he seeks to establish a purely arbitrary distinction between the causes leading to the development of the human being anterior to birth and subsequent to birth—the stimulus in the one case, he says, being nutriment, and in the other use. As an illustration of his position, Mr. Reid said (p. 293):—"Thus, if the limb of an infant be paralysed it grows comparatively little, and the muscles atrophy." But this is by no means to be taken as a simple illustration of the fact that the muscles will not develop except under the stimulus of use, because the illustration ignores the fact that what happens in the way of retarded growth of the paralysed limb, together with actual atrophy of muscles, is, quite apart from the lack of use, largely due to a severance of the normal relations between the limb and the great nerve centres, and the

consequent cutting off of the "trophic influence" exercised by the latter.

Again, it is a part of Mr. Reid's doctrine, as he tells us, to regard the power of walking and the power of speaking as use acquirements, while I, on the contrary, hold that the effects of use-exercise *seem* to be predominant in these cases simply because the efforts made to walk or to talk take place *pari passu* with the development of the nerve centres concerned with such accomplishments.

As I have said elsewhere ("The Brain as an Organ of Mind," p. 562), "the helpless condition of the infant monkey and of the human infant at birth are similarly to be ascribed, in great part, to the immature condition of their great nerve centres. Many of the movements which they slowly learn to perform are doubtless rendered possible by, and acquired coincidently with, the *actual development of those nerve cells and fibres in the spinal cord and medulla which are instrumental in the execution of such movements*. Thus, when we say that the young child 'learns' to perform these movements, it should be understood that this word is here applicable only in a very qualified sense. . . . But for the existence of this organic *nisus* (in the form of an inherited tendency to develop in certain modes and directions) the human infant could never so readily as it does acquire the power of executing the excessively complex movements which are concerned in standing, in walking, or in articulate speech."

In illustration of these views I have cited cases in which walking was an untaught act in a child at the end of her second year, as there had been no previous trials and failures; and also a case (*loc. cit.*, p. 607) in which a child who had been absolutely dumb up to the end of his fifth year suddenly began to speak under an emotional stimulus. Another very similar modern case, as well as two cases recorded by ancient writers, of untaught acts of speech are also cited in my work on "Aphasia and other Speech Defects" (1898, pp. 6-8).

No explanation of such facts seems possible except on the supposition that speech has now become a truly automatic act for human beings. Such untaught acts of speech would not, however, be possible unless cerebral development had been taking place in a normal manner, and unless the auditory sense and intelligence were unaffected.

These are some of the reasons why I dissent from Mr. Reid's view that "in man the main difference between the infant and the adult is due to use acquirements made by the latter during development," and why I say that post-natal growth and development are essentially due to the same inherent causes as pre-natal growth, notwithstanding the fact that use-exercise comes in as a powerful aid during the former period.

As to the extraordinary power of memorising shown by Chinese and Mohammedan children to which I referred Mr. Reid, in accordance with his views he would deny that any influence is to be ascribed to the practice in memorising carried on by ancestors of the children through very many previous generations; and in that case he must suppose that English children, as a class, should be capable of showing similar feats of memory, even though their ancestors had not been accustomed to any extraordinary exercise of their memorial faculty.

For the rest, that Mr. Reid's views do not suffice to close the controversy as to the inheritance of "acquired" characters may be easily seen by any of your readers who will refer to Herbert Spencer's "Principles of Biology," revised edition, 1898, App. C, pp. 692-695, and to his "Facts and Comments," 1902, pp. 92-96. I might even venture to refer your reviewer, "A. D. D.," to a consideration of the facts and arguments set forth in these works.

H. CHARLTON BASTIAN.

The Athenæum, London, February 15.

I SAID that acquirements are just as "innate" as "inborn" characters. Dr. Bastian read this—I am sure I cannot imagine why—as implying a denial of the occurrence of variations. I repudiated his interpretation, and this he now terms an admission! The muscles of a limb atrophy equally when they are rendered useless by joint disease as when there is "severance between the limb and the great nerve centres."

NO. 2000, VOL. 77]

The Lamarckian doctrine is founded on two unproved assumptions:—(1) that use causes development in all characters, and (2) that parental acquirements tend to affect the germ-cells in such a way that the traits which arise in the parent under the stimulus of use are reproduced by offspring under the stimulus of nutriment—that is, when the parent acquires one thing the child is supposed to "inherit" something inherently different and much less useful. The second assumption was formerly universal, but has now been abandoned by the vast majority of biologists. Most of us know, or think we know, how great an obstacle it was to the attainment of truth and how much deeper and clearer has become our knowledge of nature since its abandonment. We suppose it was held merely because men tend to accept current beliefs without bestowing on them that critical and sceptical thought which is one of the essentials of real scientific work.

The first assumption is still very generally made, and I think for the same reason. Unsupported by an iota of evidence and obscuring the fact that a principal feature of the evolution of the higher animals has been the evolution of a power of developing under the stimulus of use, it is as great an obstacle to the recognition of truth as the other. Many human structures are plainly incapable of developing under the stimulus of use, for example, hair, teeth, external ears, and memory. These are wholly "inborn" (*i.e.* developed under the stimulus of nutriment). The evidence seems massive that many lower animals, for example, the Coleoptera and Lepidoptera, owe little or no part of their physical and mental development to use. Hence their lack of individual adaptability. But higher in the animal scale, memory (the power of profiting by mental experience, of growing mentally under the stimulus of use) becomes apparent, and increases until it bestows on man all that makes him preeminently the educable, rational, and adaptable being. *Pari passu* with this increase of the power of growing mentally under the stimulus of use has occurred an equally great evolution of the power of growing physically under the same stimulus. In my view, then, (1) while memory and the homologous power of growing physically are "inborn," all that arises from the exercise of them is "acquired"; (2) not all human characters are capable of developing under the stimulus of use, but only a majority of them; and (3) in the case of the latter all, or nearly all, that separates the infant from the adult is due to the stimulus of use.

Either Dr. Bastian is putting the cart before the horse or I am. I believe, for example, that use develops body and mind until we are able to walk, talk, and so forth. He believes, apparently, that we would develop physically and mentally into mature men, and would walk and talk and get a knowledge of Latin and so on even if we never used body and mind. The blessed words "trophic influences" and "organic nisus" afford him complete satisfaction. Surely his assumption is made "in the face of multitudinous difficulties." To him man's adaptability, the vastness of his memory, the great development in him of the instincts of sport, curiosity, and imitiveness, which impel him to make precisely the physical and mental acquirements which bring him into harmony with his own individual environment, tell no tale. He is in a position as unhappy as those investigators who, before defining what they mean by "inheritable," spend years of labour in ascertaining exactly what is "inherited."

Mr. Cunningham says, "innate characters are those which develop without any stimulus except what Dr. Reid calls the stimulus of nutrition," or nutriment as I prefer to term it. But is not nutriment "external"? A scar cannot develop under this stimulus, and I imagine it would puzzle Mr. Cunningham to explain in what sense nutriment is more innate than injury or use. Obviously all characters develop under the influence of some *external* stimulus, and the distinctions between characters are due, not to greater or lesser innateness, but to the kinds of stimuli that cause them to appear. Acquirements arise for precisely the same reason that all inborn characters arise—because evolution has created the power of responding in quite definite ways to quite definite external stimuli; clearly, then, they are innate in precisely the same sense as inborn characters.

February 21.

G. ARCHDALL REID.